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AN INVESTIGATION OF THE CONDITION OF THE DRINKING WATER ON TRAINS OPERATING IN OR THROUGH KANSAS, . . *N. P. Sherwoo* .

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

VOL. X, NO. 2.] JANUARY, 1917. [WHOLE SERIES VOL. XX, NO. 2.

An Investigation of the Condition of the Drinking Water on Trains Operating In or Through Kansas.*

BY N. P. SHERWOOD.

(From the Department of Bacteriology of the University of Kansas, Lawrence.)

AT the request of Dr. S. J. Crumbine, secretary of the Kansas State Board of Health, an examination of the drinking water on trains that operate in or through Kansas was begun on May 23, 1912, at the Kansas City union station. A similar examination was made at Wichita on May 29 and 30. Fifty-four samples were taken at Kansas City from trains on the Frisco, Santa Fe, M. K. & T., Missouri Pacific, Burlington and Union Pacific railroads. The samples were plated on plain agar immediately after collection, and a set of six fermentation tubes containing Jackson's lactose-bile[1] were also inoculated. Five of these tubes were each inoculated with 1 cc. of the sample of water, and 10 cc. of the sample was planted into one large fermentation tube. This was done in order to determine approximately how many, if any, *B. coli* were present. These plates and tubes were then incubated for twenty-four hours at 37° C., and counts made.

There are present, even in good drinking-water, a few harmless bacteria, the number varying largely with the source of supply. These harmless water bacteria, however, thrive best at room temperature, and are, as a rule, inhibited when incubated at 37° C., or body temperature.

Mathews,[2] in 1893, showed that in streams presumably exposed to pollution the count at 37° C. was in the neighborhood of 100 per cc., while for unpolluted water from wells, springs and taps the count was under 30 per cc. Gage[3] has shown that for clean,

*Read before the Kansas State Board of Health, June 6, 1912.

1. Jour. Infec. Dis., March, 1906.

2. Technology Quarterly VI, 241.

3. A Study of the Number of Bacteria Developing at Different Temperatures, and of the Relation between such Numbers with Reference to their Significance in the Interpretation of Water Analysis.—Biological Studies by the Pupils of William Thompson Sedgwick, Boston, 1906.

unpolluted water the number of organisms developing at 37° C. is quite small, being, as a rule, under 50 per cc., while for polluted water the count is high. Too much stress must not be laid upon the count alone, yet one can get some idea as to whether the water is at least clean or dirty by the number of bacteria developing at the body temperature.

For a long time bacteriologists considered that the character of a water could be determined by the number of bacteria developing on agar and gelatine. Eventually bacteriologists realized that the quality or kind of bacteria present, as well as the quantity, is of prime importance. The customary qualitative test made on any sample of water is one to determine whether *Bacillus coli* is present, and if so, in what quantity. A test is made for this particular intestinal organism, because if it is present it is easily found and identified, and since it is a normal inhabitant of the colon or large intestines of warm-blooded animals, it indicates, when present in sufficient quantity, *i. e.*, 1 per cc. or more, pollution with animal waste.

In England, where the sewage is much more concentrated than in America, sewage streptococci are looked for in water examination instead of *B. coli*. The English argue, with reason, that the sewage streptococci are more delicate than *Bacillus coli*, and hence their presence in a water is a certain indication of *recent* sewage pollution. In these examinations streptococci were looked for as well as *Bacillus coli*. Daniel D. Jackson, in the *Journal of Infectious Diseases*, March, 1907, defines *Bacillus coli* as a Gram negative organism capable of fermenting both dextrose and lactose, with the production of carbon dioxide and hydrogen, which does not liquefy gelatin in fourteen days and which is morphologically a rod.

It is a well-known fact that ordinary ox bile has an inhibitive action on the majority of bacteria outside of those belonging to the typhoid and colon groups. Also that comparatively few organisms outside the colon group ferment lactose. Hence lactose bile—ordinary ox bile to which has been added one per cent peptone and one per cent lactose—is a medium made use of in examining a water for *Bacillus coli*. Measured quantities of water are added to fermentation tubes containing lactose bile; and if *Bacillus coli* is present the lactose will be fermented and carbon dioxide and hydrogen will be given off. When gas showed up in any of the fermentation tubes, confirmatory tests were made to see whether it was *B. coli* or some other organism that was causing

the fermentation. As a rule, in about 90 per cent of the cases *B. coli* will be found to be the active agent. *Streptococcus pyogenes* was finally identified by its characteristic growth on blood agar. As a general thing, only one sample was taken from each train, and that was collected from the chair car next to the smoker.

The results of the work done at Kansas City, Mo., and at Wichita, Kan., are shown by the tables on pages 16, 17, and 18.

Report on examination of water taken from coolers of trains arriving and departing from Kansas City, Mo., and Wichita, Kan.

FROM KANSAS CITY, MO., MAY 23 AND 24, 1912.

Sample No.	Train No.	Name of Railroad.	Time.	Train arriving or departing.	Date, 1912.	Bacteria per cc. on agar at 37° C, 24 hours.	Gas in lactose bile.							Approximate number of *B. coli* per 10 cc.	Remarks.
							1 cc.					10 cc.	Confirmatory test.		
							1	2	3	4	5				
1	102	Frisco	5:00 p. m.	A	5–23	100	–	–	–	–	–	–	None.	None.	
2	125	Frisco	5:05 p. m.	D	5–23	150	–	–	–	–	–	–	.....	None.	
3	10	A. T. & S. F.	5:05 p. m.	D	5–23	650	–	–	–	–	–	–	.....	None.	
4	24	M. K. & T.	5:05 p. m.	A	5–23	300	–	–	–	–	–	–	.....	None.	
5	12	Rock Island	5:10 p. m.	A	5–23	1,400	–	–	–	–	–	–	.....	.....	
6	29	M. K. & T.	5:30 p. m.	D	5–23	250	–	–	–	–	–	–	.....	.....	
7	137	Frisco	5:35 p. m.	D	5–23	850	–	–	–	–	–	–	.....	.....	
8	1	Mo. Pacific	6:00 p. m.	D	5–23	1,200	+	–	–	–	–	+	+	2	
9	39	Rock Island	6:10 p. m.	D	5–23	200	–	–	–	–	–	–	.....	.....	
10	106	Mo. Pacific	6:15 p. m.	A	5–23	400	–	–	–	–	–	+	+	1	
11	105	Frisco	6:15 p. m.	D	5–23	750	+	–	+	–	–	+	+	4	
12	119	Mo. Pacific	6:20 p. m.	D	5–25	800	+	+	–	–	–	+	+	4	
13	43	Burlington	6:35 p. m.	D	5–23	500	–	–	–	–	–	–	–	None.	
14	111	Frisco	9:10 p. m.	D	5–23	500	–	–	–	–	–	+	+	1	
15	11	A. T. & S. F.	9:25 p. m.	D	5–23	650	–	+	–	–	–	+	+	2	
16	36	Rock Island	9:45 p. m.	A	5–23	250	–	–	–	–	–	–	.....	None.	
17	103	Mo. Pacific	9:50 p. m.	D	5–23	300	–	–	–	–	–	–	.....	None.	
18	17	A. T. & S. F.	10:00 p. m.	D	5–23	800	–	–	–	–	–	–	.....	None.	
19	21	M. K. & T.	10:00 p. m.	D	5–23	950	–	+	+	–	–	+	+	4	
20	112	Mo. Pacific	10:20 p. m.	A	5–23	150	–	–	–	–	–	–	.....	None.	
21	203	A. T. & S. F.	10:45 p. m.	D	5–23	1,100	–	–	–	–	–	–	.....	None.	
22	1	Rock Island	11:15 p. m.	D	5–23	800	+	+	–	+	–	+	+	6	
23	23	Rock Island	11:30 p. m.	D	5–23	250	–	–	–	–	–	–	.....	None.	
24	25	M. K. & T.	2:20 a. m.	D	5–24	1,500	–	–	–	–	–	+	+	1	
25	210	Mo. Pacific	2:00 a. m.	D	5–24	40	–	–	–	–	–	–	–	None.	
26	23	Rock Island	6:15 a. m.	A	5–24	250	–	–	–	–	–	+	+	1	
27	8	A. T. & S. F.	6:30 a. m.	A	5–24	700	–	–	–	–	–	–	–	None.	*Streptococcus pyogenes* present.
28	18	A. T. & S. F.	7:00 a. m.	A	5–24	550	–	–	–	–	–	–	.....	None.	
29	12	A. T. & S. F.	7:10 a. m.	A	5–24	620	–	–	–	–	–	–	.....	None.	
30	104	Frisco	7:00 a. m.	A	5–24	200	–	–	–	–	–	–	.....	None.	
31	22	M. K. & T.	7:20 a. m.	A	5–24	300	–	–	–	–	–	–	.....	None.	
32	35	Rock Island	7:55 a. m.	D	5–24	1,000	–	–	–	–	–	+	–	None.	*B. mycoides.*
33	113	A. T. & S. F.	8:01 a. m.	D	5–24	600	–	–	–	–	–	–	.....	None.	
34	107	Union Pacific	8:05 a. m.	D	5–24	1,100	–	–	–	–	–	–	–	1	*Streptococcus pyogenes* present.
35	111	Mo. Pacific	8:15 a. m.	D	5–24	1,000	+	–	+	+	+	+	+	8	
36	127	Frisco	8:30 a. m.	D	5–24	30	–	–	–	–	–	+	Bubble.	None.	*B. mycoides.*

FROM KANSAS CITY, MO., MAY 23 AND 24, 1912—CONCLUDED.

Sample No.	Train No.	NAME OF RAILROAD.	Time.	Train arriving or departing.	Date, 1912.	Bacteria per cc. on agar at 37° C, 24 hours.	Gas in lactose bile.							Approximate number of *B. coli* per 10 cc.	Remarks.
							1 cc.					10 cc.	Confirmatory test.		
							1	2	3	4	5				
37	201	A. T. & S. F.	9:00 a. m.	D	5–24	150	−	−	−	−	−	−	.....	None.	———
38	3	A. T. & S. F.	9:10 a. m.	D	5–24	1,200	−	+	+	+	−	+	+	6	———
39	110	Union Pacific	9:15 a. m.	A	5–24	1,800	+	+	+	+	+	+	+	10	———
40	102	Mo. Pacific	9:20 a. m.	A	5–24	700	+	+	+	−	−	+	+	6	———
41	518	A. T. & S. F.	9:40 a. m.	D	5–24	100	−	−	−	−	−	−	.....	None.	———
42	112	Frisco	9:59 a. m.	A	5–24	1,250	−	−	−	−	−	+	+	1	———
43	9	A. T. & S. F.	9:20 a. m.	A	5–24	950	+	+	−	−	+	+	+	6	———
44	11	Rock Island	10:10 a. m.	D	5–24	500	−	−	−	−	−	−	.....	None.	———
45	110	A. T. & S. F.	—— a. m.	A	5–24	400	−	−	−	−	−	−	.....	None.	———
46	.....	.....	—— a. m.	.....	5–24	500	−	−	−	−	−	+	+	1	———
47	.....	.....	—— a. m.	.....	5–24	900	−	−	−	−	−	+	+	1	———
48	531	Mo. Pacific	4:05 p. m.	D	5–24	75	−	−	−	−	−	−	−	None.	———
49	105	Union Pacific	4:10 p. m.	D	5–24	1,200	−	−	−	−	−	−	−	None.	———
50	1316	Frisco	4:15 p. m.	A	5–24	90	−	−	−	−	−	−	.....	None.	———
51	111	A. T. & S. F.	4:15 p. m.	A	5–24	1,200	−	−	−	−	−	−	.....	None.	———
52	109	A. T. & S. F.	4:30 p. m.	A	5–24	800	−	−	−	−	−	−	.....	None.	———
53	131	Mo. Pacific	4:30 p.	D	5–24	850	−	−	−	−	−	−	−	None.	———
54	5	A. T. & S. F.	9:40 p. m.	D	5–24	30	−	−	−	−	−	−	.. ..	None.	Chair car.
55	5	A. T. & S. F.	9:40 p. m.	D	5–24	25	−	−	−	−	−	−	.....	None.	Smoking car.
.....	.....	Tap	.....	.....	5–24	20	−	−	−	−	−	−	.....	None.	Station.
.....	.....	Union Pacific*	.....	.....	5–24	30	−	−	−	−	−	−	.....	None.	———

*Sand springs water.

FROM WICHITA, KAN., MAY 29 AND 30, 1912.

Sample No.	Train No.	Name of Railroad.	Time.	Train arriving or departing.	Date, 1912.	Bacteria per cc. on agar at 37° C, 24 hours.	Gas in lactose bile.							Approximate number of *B. coli* per 10 cc.	Remarks.
							1 cc.					10 cc.	Confirmatory test.		
							1	2	3	4	5				
1	12	A. T. & S. F.	12:26 a. m.		5–30	130	–	–	–	–	–	–		None.	
2	32	Rock Island	12:55 a. m.		5–30	150	–	–	–	–	–	–		None.	
3	403	Mo. Pacific	7:30 a. m.		5–30	400	–	–	–	–	–	–		None.	*B. pyocyaneus* present; iced at Yates Center.
4	433	Mo. Pacific	7:50 a. m.		5–30	300	–	–	–	–	–	–		None.	*B. pyocyaneus* present; iced and H_2O at Wichita.
5	703	Mo. Pacific	7:45 a. m.		5–30	450	–	–	–	–	–	–		None.	H_2O at Wichita.
6	117	A. T. & S. F.	8:20 a. m.		5–30	1,200	+	+	+	+	+	+	+	10	
7	309	Frisco	8:25 a. m.		5–30	300	–	–	–	–	–	–		None.	Car 309. Iced at Minette and Walire.
8	309	Frisco	8:25 a. m.		5–30	150	–	–	–	–	–	–		None.	Car 1016.
9	517	A. T. & S. F., Englewood branch	8:30 a. m.	D	5–29	550	+	+	+	+	+	+	+	10	Car 137; iced and H_2O at Wichita.
10	1	Orient	8:35 a. m.	D	5–29	500	+	+	+	–	–	+	+	6	Iced and H_2O at Wichita.
11	12	Rock Island	9:50 a. m.		5–29	650	–	+	+	+	+	+	+	8	Iced at Caldwell; H_2O at Chickasha, Okla.
12	406	A. T. & S. F.	10:45 a. m.		5–29	500	–	–	–	–	–	–	–	10	Iced at Pratt, also water.
13	406	A. T. & S. F.	11:10 a. m.		5–29	600	+	+	–	–	–	+	+	4	Iced at Arkansas City; H_2O at Purcell.
14	8	Frisco	11:15 p. m.		5–29	600	–	–	–	–	–	–		None.	Car 62.
15	8	Frisco	11:15 p. m.		5–29	550	–	–	–	–	–	–		None.	Car 1030.
16	16	A. T. & S. F.	1:50 p. m.		5–29	100	–	–	–	–	–	–		None.	
17	518	A. T. & S. F., Englewood branch	1:30 p. m.	A	5–29	1,200	+	+	+	+	–	+	+	8	
18	505	A. T. & S. F.	5:25 p. m.		5–30	350	–	–	–	–	–	–		None.	*B. pyocyaneus* present.
19	710	Mo. Pacific	6:20 p. m.		5–30	300	–	–	–	–	–	–		None.	H_2O at Nevada; Ice Coffeyville.
20	405	Mo. Pacific	6:25 p. m.	A	5–30	350	–	–	–	–	–	–		None.	
21	2	Orient	7:00 p. m.	A	5–30	450	–	–	–	–	–	–		None.	
22	24	Rock Island	9:20 p. m.		5–30	500	+	+	+	+	+	+	+	10	*B. pyocyaneus* present.
23		Tap (city)	8:00 a. m.			60	–	–	–	–	–	–		None.	Tap at depot A. T. & S. F.
24	2	Midland Valley	8:00 a. m.	D		400	+	–	+	+	–	+	+	6	Iced and H_2O at Wichita.
25		Tap				90	–	–	–	–	–	–		None.	Tap at Mo. Pacific.
26		Tap				80	–	–	–	–	–	–		None.	Tap at Rock Island.
27		Tap				60	–	–	–	–	–	–		None.	Tap at Frisco.

Altogether there were seventy-eight samples taken, and in order to simplify matters these have been rearranged into four groups according to the degree of pollution, beginning with the worst samples in group I and ending with the purest water in group IV.

Group I includes all those samples having at least 10 colon organisms in 10 cc. of water, or 1 per cc. of the water examined, and is as follows:

GROUP I.

City.	Sample No.	Train No.	Name of Railroad.	Time.	Arriving or departing.	Date.	Count per cc. on agar at 37° C., 24 hours.	Approximate number of *B. coli* in 10 cc.
Kansas City, Mo..	39	110	Union Pacific....	9:15 p. m.	A	5–24	1,800	10
Wichita.....	6	117	A. T. & S. F.....	8:20 p. m.	D	5–29	1,200	10
Wichita.....	9	517	A. T. & S. F., Englew'd branch,	8:30 a. m.	D	5–29	550	10
Wichita.....	12	506	A. T. & S. F.....	10:45 a. m.	.....	5–29	500	10
Wichita.....	22	24	Rock Island.....	9:20 p. m.	.....	5–30	500	10

Group II includes those having from 6 to 8 *B. coli* in 10 cc. of water:

GROUP II.

City.	Sample No.	Train No.	Name of Railroad	Time.	Arriving or departing.	Date.	Count per cc. on agar at 37° C., 24 hours.	Approximate number of *B. coli* in 10 cc.
Kansas City, Mo..	1	1	Rock Island.....	11:15 p. m.	D	5–23	800	6
Kansas City, Mo..	35	111	Missouri Pacific...	8:15 a. m.	D	5–24	1,000	8
Kansas City, Mo..	38	3	A. T. & S. F.....	9:10 a. m.	D	5–24	1,200	6
Kansas City, Mo..	40	102	Missouri Pacific...	9:20 a. m.	A	5–24	700	6
Wichita.....	1	1	Orient.....	8:35 a. m.	D	5–29	500	6
Wichita.....	11	12	Rock Island.....	9:50 a. m.	.....	5–29	650	8
Wichita.....	17	518	A. T. & S. F., Englew'd branch,	1:30 p. m.	A	5–29	1,200	8
Wichita.....	24	2	Midland Valley...	8:00 a. m.	D	5–30	400	6

Group III: There are fourteen samples having from 1 to 4 *B. coli* per 10 cc. of the water. In two of them both *Streptococcus pyogenes* as well as *B. coli* was present.

Group IV: There are forty-nine samples in which no *B. coli* were present in 10 cc. of the water.

In group I there are five samples, or 6.4 per cent, containing 10 colon bacteria in 10 cc. of the water, or 1 per cc., with bacterial counts ranging from 500 to 1800 per cc. In one sample *Bacillus pyocyaneus*, the green-pus organism, was found to be present. Waters in this group are decidedly unfit for drinking purposes.

In group II there are nine samples, or 11.4 per cent, in which there are 6 to 8 colon organisms in each ten cc. of the water, with

the bacterial count ranging between 400 and 1200 per cc. These waters are open to strong suspicion and should not be drunk.

In group III there are fourteen samples, or 17.8 per cent, having from 1 to 4 *B. coli* in each 10 cc. of the water, with comparatively high counts.

Of the forty-nine samples in which no *B. coli* was found, twenty-two of them, or 44.9 per cent, show counts developing at body temperature of over 350 bacteria per cc. and eighteen of these have 500 or more bacteria per cc. Thirty-one samples show counts under 500 per cc., and of these twenty-seven, or about one-third of the total number of samples examined, are under 350 per cc. That is, if we attribute any significance—and we must—to the number of bacteria developing at body temperature, and adopt even 350 per cc. as a dividing line between clean and dirty water, we find that of the seventy-eight samples examined, only twenty-seven, or about one-third, showed themselves to be sufficiently clean for drinking purposes.

The possible sources of pollution in these samples of water may be grouped as follows:

1. From the original water supply.
2. From the water used in the ice.
3. From the dirt adhering to the ice.
4. From the hands or person of the individual handling the ice.
5. From the buckets, wheelbarrows, etc., used in carrying and handling the ice.
6. From carelessness in washing the tanks as to thoroughness and as to kind of water used in washing.

The following data as to the water and ice furnished passenger trains in Kansas was supplied by the railroads to Doctor Crumbine:

Railroad and Station.	Water or ice.	Source.	Method of handling.
Rock Island:			
Armourdale	Water	Railroad plant	Buckets and tongs.
Armourdale	Ice	Manufacturing plant	Buckets and tongs.
Horton	Water	Well	———
Horton	Ice	———	Tongs.
Topeka	Water	City	———
Topeka	Ice	Manufacturing plant	Buckets.
McFarland	Water	Well	———
McFarland	Ice	Manufacturing plant	Buckets.
Herington	Water	Railroad plant	———
Herington	Ice	Manufacturing plant	Tongs.
Caldwell	Water	City	———
Caldwell	Ice	Manufacturing plant	Buckets.
Liberal	Water	Railroad plant	———
Liberal	Ice	Manufacturing plant	Buckets.
Pratt	Water	Railroad plant	———
Pratt	Ice	Manufacturing plant	Buckets.
Belleville	Water	City	———
Belleville	Ice	Natural	Buckets.
Goodland	Water	Railroad plant	———
Goodland	Ice	Manufacturing plant	Buckets.
Phillipsburg	Water	Piped from Glade	———
M. K. & T.:			
Parsons	Water	City	———
Parsons	Ice	Manufacturing plant	———
Kansas City	Water	City	———
Junction City	Water	City	———
Junction City	Ice	Manufacturing plant	———
Iola	Water	City	———
Iola	Ice	Manufacturing plant	———
Union Pacific:			
Armstrong	Water	City	———
Armstrong	Ice	Natural and manufactured	———
Manhattan	Water	Railroad plant	———
Manhattan	Ice	Natural and manufactured	———
Junction City	Water	City	———
Junction City	Ice	Natural and artificial	———
Solomon	Water	Railroad plant	———
Solomon	Ice	Natural and manufactured	———
Salina	Water	Railroad plant	———
Salina	Ice	Natural and manufactured	———
Ellis	Water	Railroad plant	———
Ellis	Ice	Natural and manufactured	———
Leavenworth	Water	City	———
Leavenworth	Ice	Natural and manufactured	———
Onaga	Water	Railroad plant	———
Onaga	Ice	Natural and manufactured	———
Miltonvale	Water	Railroad plant	———
Miltonvale	Ice	Natural and manufactured	———
Belleville	Water	Railroad plant	———
Belleville	Ice	Manufactured	———
Beloit	Water	Railroad plant	———
Beloit	Ice	Manufactured	———
Orient:			
Wichita	Water	Railroad plant	———
Wichita	Ice	Manufactured	———
Concordia	Water	Railroad plant	———
Concordia	Ice	Natural	Buckets.
Atchison	Water	City	———
Atchison	Ice	Natural	Buckets.
Oberlin	Water	Railroad plant	Put in tanks by roundhouse men.
Oberlin	Ice	———	———
St. Francis	Water	Railroad plant	Put in tanks by roundhouse men.
St. Francis	Ice	———	———

All of the water supplies investigated showed themselves to be good, potable water. An inspection of the ice used in the coolers quite often revealed the presence of dirt in artificial as well as natural ice.

The presence of *B. pyocyaneus* is of no great significance, as organisms closely resembling or identical with it are often found in normal waters. Its source could not be determined, but was probably from the air or dirt. No cuts or wounds were found on the hands of those handling the ice, water or coolers. As mentioned above, one must not lay too much stress on a body-temperature count alone, yet from the data obtained at Kansas City it will be noted that of those trains watered at Kansas City, nearly 20 per cent had counts under 100 per cc., and 12 per cent had counts of 40 per cc. or less, while the sources of supply showed a count of 20 per cc. with no *B. coli* present in 10 cc. From this data, and after making a sanitary survey of conditions, it seems that there is no excuse for so many samples having body temperature counts of over 350 per cc., and that these high counts show carelessness in cleaning the coolers and handling the ice.

The publication of this paper at this time has been made because of its historical interest and because of numerous requests for reprints of the report. It should be understood that these conditions probably in no way exist to-day since the federal government and the state of Kansas have carefully carried out investigations, and laws have been passed regulating the handling of drinking water on common carriers. This investigation which Doctor Crumbine had carried out was, perhaps, the first of its kind in the United States. As a result of it, the Kansas State Board of Health formulated rules and regulations governing drinking water on trains, which antedated the federal government's action over two years. He made use of this and other data at his command in his pioneer work for the betterment of conditions of drinking water on common carriers.

Since this investigation was made much research work and improvement has been done along lines of water investigation. The value of lactose bile has been questioned because of its inhibitive action on the colon group, and some interesting work along the line of differentiation between fecal and other strains of bacillus coli has been carried out.

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